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INTERNATIONAL PATENT APPLICATION PCT/FI2003/000529
FASTER FINE TIMING OPERATION IN MULTI-CARRIER SYSTEM
APPLICANT: NOKIA CORPORATION

Dear Sirs,

We refer to the International Search Report dated 16 January 2004.

The applicant wishes to avail himself of the provisions of Art. 19 PCT to make minor amendments to the claims. Substantive amendments consist of augmenting original claims 1, 2 and 19 to additionally mention "pilot carriers", as well as adding a new claim 14 which requires the pilot carriers to be scattered pilot carriers. Additionally an unnecessary recitation of "at least" was deleted from what originally was claim 20, and original claims 14-23 were renumbered as claims 15-24 respectively, due to the addition of a new claim 14.

Support for the explicit recitation of pilot carriers is readily found in the paragraph beginning on line 23 of oage 8 in the application as filed. The same paragraph also offers support for the fact that the pilots are scattered pilots, which is the subject of the added new claim 14.

The reason for introducing these amendments to the claims is the applicant's wish to further differentiate the invention as claimed from the teachings of the reference publications WO 01/69878 A1 and EP 0 837 582, which do not contain any reference to using pilot carriers

as the basis for defining an energy in the received signal. Quite to the contrary, WO 01/69878 A1 suggests using the unused carriers for power estimation, which is not comparable to using pilot carriers due to the completely different signal content of the two.

Yours faithfully,
BERGGREN OY AB

Matti Brax
Patent Agent

Enclosures - Amended claims in both marked-up and clean copies

Claims

1. A method for receiving a multi-carrier signal, the method comprising the steps of:

defining an energy of pilot carriers in said signal in respect of an estimated guard interval position of said signal, and

based on said energy, selecting a position for a time domain to frequency domain transform window of said signal.

2. A method according to claim 1, wherein the step of defining comprises:

defining the energy of said pilot carriers in said signal in respect of the estimated guard interval position of said signal for predetermined amount of trial positions for said time domain to frequency domain transform window,

and further the step of selecting further comprises:

selecting said position from said trial positions.

3. A method according to claims 1 or 2, wherein the selection step comprises: selecting said position for the time domain to the frequency domain transform window of said signal in such a way that the smallest amount of inter symbol interference is formed.

4. A method according to any of the preceding claims, wherein said step of selecting is based on energy outside the estimated guard interval position having the minimum.

5. A method according to any of the preceding claims, wherein said step of selecting is based on energy inside the estimated guard interval position having the maximum.

6. A method according to any of the preceding claims, wherein said step of selecting is based on an energy ratio between energy sample inside the estimated guard interval position and energy sample outside the estimated guard interval position.

7. A method according to claim 1, further comprising, before the step of defining, the step of:

performing a coarse timing for said signal for an initial position for said time domain to frequency domain transformation window.

8. A method according to claim 1, wherein the step of defining is performed according to a predetermined scheme for determining a predetermined amount of trial positions for said time domain to frequency domain transform window, and

based on said energy, selecting the time domain to frequency domain transformation window from said trial positions in such a way that the smallest amount of inter symbol interference is formed.

9. A method according to any of the preceding claims, further comprising the step of

performing a fine timing with the selected time domain to frequency domain transformation window for fine tuning said selected time domain to frequency domain transformation window.

10. A method according to claim 1, further comprising, before the step of defining, the steps of:

performing a first time interpolation for said signal,

further, before the step of selecting,

taking a certain amount of trial positions for said time domain to frequency domain transformation window in accordance with a predefined scheme,

and further,

based on said energy, selecting the time domain to frequency domain transformation window position of said trial positions with the smallest amount of interference,

initialising a second time interpolation with the selected position, and

fine tuning said time domain to frequency domain transformation window.

11. A method according to claim 10, wherein said first time interpolation comprises a linear time interpolation.

12. A method according to any of the preceding claims, wherein said time domain to frequency domain transform window of said signal comprises FFT-window.

13. A method according to any of the preceding claims, wherein said multi-carrier signal comprises a mobile IP over DVB-T signal.

14. A method according to any of the preceding claims, wherein said pilot carriers are scattered pilot carriers.

145. Data processing system comprising means for carrying out the method according to claim 1.

156. A computer program comprising computer program code means adapted to perform the method of claim 1 when said program is run on a computer.

167. A computer program as claimed in claim 156 embodied on a computer readable medium.

178. A computer readable medium comprising program code adapted to carry out the method of claim 1 when run on a computer.

189. A carrier medium carrying the computer executable program of claim 156.

~~19~~20. A receiver for receiving a multi-carrier signal, the receiver comprising:

means for defining an energy of pilot carriers in said signal in respect of an estimated guard interval position of said signal, and

based on said energy, means for selecting a position for a time domain to frequency domain transform window of said signal.

201. A receiver according to claim ~~19~~20, wherein said means for defining ~~at least~~ comprises a fine timing unit.

212. A receiver according to claim ~~19~~20, wherein said means for selecting comprises a fallback unit for tracking predetermined trial positions for time domain to frequency domain transform window and a control unit for selecting the position from said trail positions.

223. A system for receiving a multi-carrier signal, the system comprising:

means for determining a predetermined amount of trial positions for FFT-window according to a predetermined scheme,

means for defining energy for each trial position in respect of an estimated guard interval position of said signal, and

means for selecting a position from said trial positions for said FFT-window in such a way that the smallest amount of interference is formed for a desired signal.

234. A method for receiving an OFDM radio signal, comprising the steps of:

(a) receiving said signal,

(b) selecting an initial position for a FFT-window of said signal in accordance with a coarse timing,

(c) performing FFT to said initial position to obtain a first output,

(d) extracting scattered pilots from said first output to obtain a second output,

(e) performing a linear time interpolation for said second output,

(f) performing IFFT for the time interpolated scattered pilots for obtaining a channel impulse response (CIR),

(g) estimating energy based on the CIR,

(h) keeping track on used trial positions with said energy,

(i) changing FFT-window position in accordance with a predefined scheme until predefined amount of trial positions for said FFT-window have been applied,

(j) selecting a FFT-window from said trial positions,

(k) performing a time interpolation for the scattered pilots based on the selected FFT-window,

(l) performing IFFT for the time interpolated scattered pilots, and

(m) fine tuning the selected FFT-window in accordance with the IFFT.

Claims

1. A method for receiving a multi-carrier signal, the method comprising the steps of:

defining an energy of pilot carriers in said signal in respect of an estimated guard interval position of said signal, and

based on said energy, selecting a position for a time domain to frequency domain transform window of said signal.

2. A method according to claim 1, wherein the step of defining comprises:

defining the energy of said pilot carriers in said signal in respect of the estimated guard interval position of said signal for predetermined amount of trial positions for said time domain to frequency domain transform window,

and further the step of selecting further comprises:

selecting said position from said trial positions.

3. A method according to claims 1 or 2, wherein the selection step comprises: selecting said position for the time domain to the frequency domain transform window of said signal in such a way that the smallest amount of inter symbol interference is formed.

4. A method according to any of the preceding claims, wherein said step of selecting is based on energy outside the estimated guard interval position having the minimum.

5. A method according to any of the preceding claims, wherein said step of selecting is based on energy inside the estimated guard interval position having the maximum.

6. A method according to any of the preceding claims, wherein said step of selecting is based on an energy ratio between energy sample inside the estimated guard interval position and energy sample outside the estimated guard interval position.

7. A method according to claim 1, further comprising, before the step of defining, the step of:

performing a coarse timing for said signal for an initial position for said time domain to frequency domain transformation window.

8. A method according to claim 1, wherein the step of defining is performed according to a predetermined scheme for determining a predetermined amount of trial positions for said time domain to frequency domain transform window, and

based on said energy, selecting the time domain to frequency domain transformation window from said trial positions in such a way that the smallest amount of inter symbol interference is formed.

9. A method according to any of the preceding claims, further comprising the step of

performing a fine timing with the selected time domain to frequency domain transformation window for fine tuning said selected time domain to frequency domain transformation window.

10. A method according to claim 1, further comprising, before the step of defining, the steps of:

performing a first time interpolation for said signal,

further, before the step of selecting,

taking a certain amount of trial positions for said time domain to frequency domain transformation window in accordance with a predefined scheme,

and further,

based on said energy, selecting the time domain to frequency domain transformation window position of said trial positions with the smallest amount of interference,

initialising a second time interpolation with the selected position, and

fine tuning said time domain to frequency domain transformation window.

11. A method according to claim 10, wherein said first time interpolation comprises a linear time interpolation.

12. A method according to any of the preceding claims, wherein said time domain to frequency domain transform window of said signal comprises FFT-window.

13. A method according to any of the preceding claims, wherein said multi-carrier signal comprises a mobile IP over DVB-T signal.

14. A method according to any of the preceding claims, wherein said pilot carriers are scattered pilot carriers.

15. Data processing system comprising means for carrying out the method according to claim 1.

16. A computer program comprising computer program code means adapted to perform the method of claim 1 when said program is run on a computer.

17. A computer program as claimed in claim 16 embodied on a computer readable medium.

18. A computer readable medium comprising program code adapted to carry out the method of claim 1 when run on a computer.

19. A carrier medium carrying the computer executable program of claim 16.

20. A receiver for receiving a multi-carrier signal, the receiver comprising:

means for defining an energy of pilot carriers in said signal in respect of an estimated guard interval position of said signal, and

based on said energy, means for selecting a position for a time domain to frequency domain transform window of said signal.

21. A receiver according to claim 20, wherein said means for defining comprises a fine timing unit.

22. A receiver according to claim 20, wherein said means for selecting comprises a fallback unit for tracking predetermined trial positions for time domain to frequency domain transform window and a control unit for selecting the position from said trail positions.

23. A system for receiving a multi-carrier signal, the system comprising:

means for determining a predetermined amount of trial positions for FFT-window according to a predetermined scheme,

means for defining energy for each trial position in respect of an estimated guard interval position of said signal, and

means for selecting a position from said trial positions for said FFT-window in such a way that the smallest amount of interference is formed for a desired signal.

24. A method for receiving an OFDM radio signal, comprising the steps of:

(a) receiving said signal,

(b) selecting an initial position for a FFT-window of said signal in accordance with a coarse timing,

(c) performing FFT to said initial position to obtain a first output,

(d) extracting scattered pilots from said first output to obtain a second output,

(e) performing a linear time interpolation for said second output,

(f) performing IFFT for the time interpolated scattered pilots for obtaining a channel impulse response (CIR),

(g) estimating energy based on the CIR,

(h) keeping track on used trial positions with said energy,

(i) changing FFT-window position in accordance with a predefined scheme until predefined amount of trial positions for said FFT-window have been applied,

(j) selecting a FFT-window from said trial positions,

(k) performing a time interpolation for the scattered pilots based on the selected FFT-window,

(l) performing IFFT for the time interpolated scattered pilots, and

(m) fine tuning the selected FFT-window in accordance with the IFFT.